PROCEEDINGS

FOURTH ANNUAL GULF OF MEXICO INFORMATION TRANSFER MEETING

International Hotel
New Orleans, Louisiana
15-17 November 1983

SPONSORED BY

MINERALS MANAGEMENT SERVICE
GULF OF MEXICO REGIONAL OFFICE

Arrangements Handled by

Science Applications Incorporated
Raleigh, North Carolina

and

Department of Conferences and Workshops
University of Southern Mississippi
Long Beach, Mississippi

Session: DETECTION AND EVALUATION OF INUNDATED PREHISTORIC SITES

Chairmen: Ms. Melanie Stright
Mr. Brent Smith

Date: November 16, 1983

Presentation Title	Speaker/Affiliation
Session Overview	Ms. Melanie Stright MMS, Gulf of Mexico Region
Testing the Model for Prehistoric Site Occurrence on the Gulf of Mexico Outer Continental Shelf	Dr. Sherwood Gagliano Coastal Environments, Inc.
A Predictive Model for Marine Sites in Washington State	Ms. Jacqueline M. Grebmeier University of Alaska
The Geologic Context of the McFaddin Beach Area, Southeast Texas	Dr. Saul Aronow Lamar University
Archaeology and Paleogeography of the McFaddin Beach Site, Jefferson County, Texas	Dr. Charles Pearson Coastal Environments, Inc.
The Effects of Sea Level Rise and Subsidence on Prehistoric Sites in Coastal Louisiana	Mr. Thomas Ryan U.S. Army Corps of Engineers New Orleans District
Potentials of Discovery of Human Occupation Sites on the Continental Shelves and Nearshore Coastal Zone	Dr. Daniel Belknap University of Maine
Submarine Stone Age Settlements in Denmark	Mr. Per Smed Philipsen Danish Ministry of the Environment

DETECTION AND EVALUATION OF INUNDATED PREHISTORIC SITES

SESSION OVERVIEW

Ms. Melanie Stright
MMS, Gulf of Mexico Region

For the last decade there has been a growing awareness among the professional archaeological community, that for time periods prior to about 5,000 B.P. (when sea level reached its current high stand) the subaerially exposed continental land mass was much larger than at present. Therefore, prehistoric site patterns, cultural contacts, and subsistence strategies observable on the present land mass only represent a portion of the archaeological record.

In response to this growing concern for inundated historic and prehistoric sites, and in order to comply with the requirements of Section 106 of the National Historic Preservation Act of 1966, as amended, the Department of Interior began requiring remote sensing surveys for the detection of historic shipwrecks and inundated prehistoric archaeological sites prior to lease development on the Outer Continental Shelf.

The technology and methods for locating and evaluating submerged prehistoric sites have developed rapidly and employ techniques from many other fields, e.g., geophysics, geomorphology, sedimentology, oceanography, and chemistry. These techniques and methods are employed in three major lines of analysis:

1) potential for site occurrence
2) potential for site preservation
3) potential for locating and evaluating sites when they occur.

Last year's session on prehistoric archaeology centered on techniques for locating and evaluating sites within areas having a high potential for site occurrence and preservation. Papers this year concentrated on techniques for predicting site locations and preservation potential.

The models and techniques presented in this session were particularly important and timely since a study designed to locate submerged prehistoric sites in the Central Gulf of Mexico is currently underway. This study will test our ability to predict site locations on the now submerged shelf, and determine the applicability and adequacy of current methods and technology for testing and evaluating these potential site locations.

TESTING THE MODEL FOR PREHISTORIC SITE OCCURRENCE ON THE GULF OF MEXICO OUTER CONTINENTAL SHELF

Sherwood M. Gagliano
Coastal Environments, Inc.

It has been hypothesized that prehistoric archaeological sites are preserved in certain locales on the northern Gulf of Mexico Outer Continental Shelf. A model of settlement and site preservation has been presented which relies on factors of sea level change, potential for preservation of landform features during marine transgression, and the relationship between prehistoric site occurrence and landforms as derived from terrestrial analogs. Prospecting for drowned terrestrial sites is possible with available geophysical techniques and identification of cultural deposits can be achieved through analysis of core samples. The buried Sabine Trench off of the eastern Texas coast has been selected as a suitable area for testing the proposed settlement model. The trench contains buried preserved landforms of late Pleistocene and Holocene age which correspond to high probability areas of site occurrence as defined in the model. The potential for site preservation in the Trench was discussed. The data collection and analytical techniques to be used, which include fine scaled seismic survey and the collection of vibra-cores, were reviewed.

A PREDICTIVE MODEL FOR MARINE SITES IN WASHINGTON STATE

Jacqueline M. Grebmeier
University of Alaska

During the Pleistocene sea levels were lowered several hundred feet opening up large areas of the continental shelf for human occupation. For many years archaeologists have assumed that coastal sites of late Pleistocene age were destroyed by rising sea levels at the end of the glacial period. Recent advances in marine archaeology have suggested however, that such sites may still be accessible for archaeological study (Ruppe, 1980).

At the Center for Marine Archaeology we have been developing a model to predict submerged prehistoric site locations in the Puget Sound Lowland as part of an overall inventory and management plan for the State of Washington. The Center for Marine Archaeology is directed by Dr. William C. Smith of Central Washington University and partial support for this research was provided by the Washington State Office of Archaeology and Historic Preservation. Following a brief discussion of the concept of predictive modeling I will comment on the Northwest Pleistocene environment, the environmental and cultural parameters used for site prediction, the results thus far obtained, and some direction for further research.

Predictive modeling in site location operates in the following manner. It identifies known prehistoric sites in an area, determines their relationship to identifiable features of the natural environment and extrapolates these factors to an entire study area so as to predict where sites may occur. The work of Gagliano et al. (1977) on the continental shelf of the Gulf of Mexico is representative of predictive survey methods in the study of submerged sites. This study established predictive zones based on the analysis of submarine topography and geology, eustatic sea level changes, and onshore prehistoric settlement patterns.

To develop a workable model for the Puget Sound area it is important to have an understanding of the geological history of the region. In northwest Washington the last glacial phase was dominated by the Cordilleran ice sheet moving down from Canada. The major glacial episode in the Puget Lowland and Strait of Juan de Fuca during this time was the Vashon Stade of the Fraser Glaciation. The ice mass split into two lobes: the Juan de Fuca lobe that moved westward to the Pacific Ocean, and the Puget Sound lobe that extended just south of Olympia. Glacial erosion expanded pre-existing river valleys, forming fjord-like troughs to depths of about 300 meters below present levels (Thorson, 1980).

Ice began receding at the toes of both lobes prior to 14,000 B.P., with the Juan de Fuca lobe at a faster rate. Once the ice dam at Admiralty Inlet broke, about 13,000 B.P., marine waters entered Puget Sound depositing glaciomarine sediments on top of Vashon till. As Vashon ice thinned and was bouyed up by marine waters, land level relative to the sea was approximately 80-140 meters lower than present (Easterbrook, 1969).

Once free of the weight of ice, the land began to rise or "rebound," with the rate of uplift greatest during and soon after unloading. These rebound rates, in conjuction with sea level rise, have located glaciomarine drift up to 140 meters above present sea level in the northern Puget Lowland. Figure 27 shows curves of isostatic rebound rate, eustatic sea level rise, and relative sea level estimates for various time periods at Whatcom County in the northern Puget Lowland (Larsen, 1972).

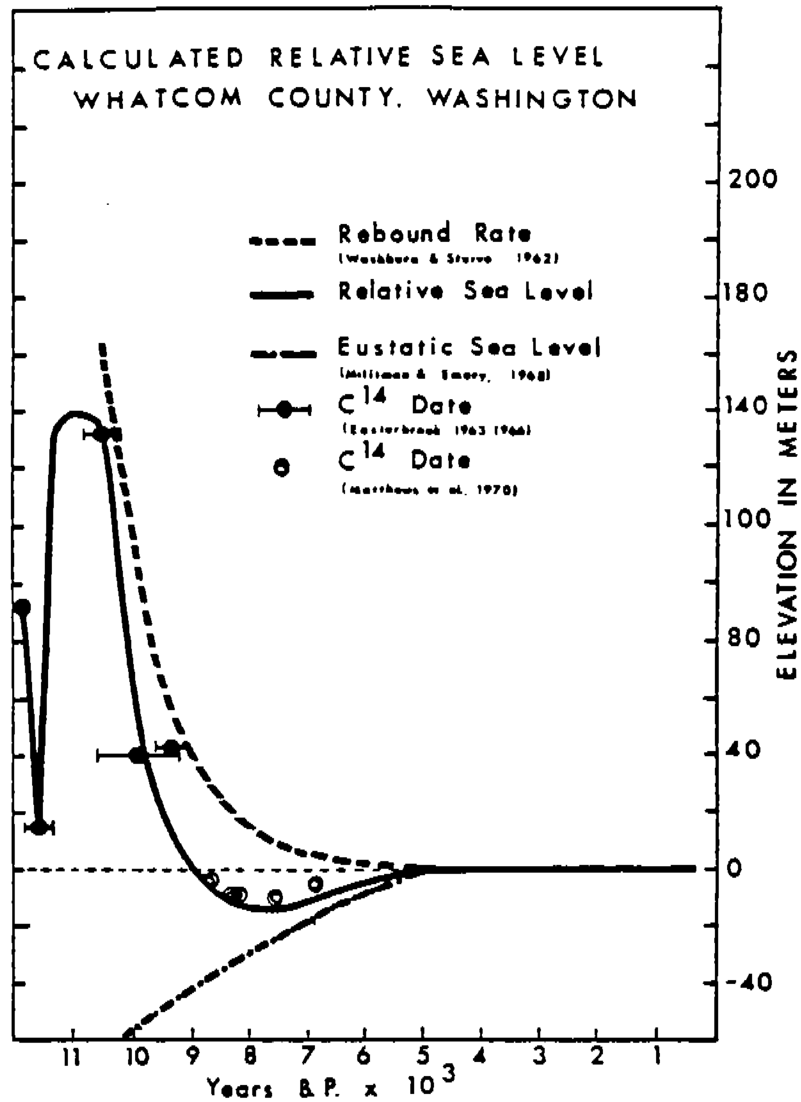


Figure 27. Calculated Relative Sea Level, Whatcom County, Washington. Reproduction by permission of author of graph.

It is important to note the major environmental changes--isostatic rebound, eustatic sea level rise, and to a minor degree tectonic movements--that occurred between 11,000 and 9,000 B.P. (Figure 27). A rapid relative sea level drop from 140 meters above present sea level at 11,000 B.P. to 10 meters below present sea level by 9,000 B.P. shows the dramatic effect where rebound rate exceeds sea level rise.

The goal of developing this predictive model is to delineate high probability areas for submerged prehistoric sites along the Strait of Juan de Fuca and Puget Sound Lowland. Present emphasis is on the northern Puget Sound.

In the development of the model certain assumptions and parameters were chosen as a baseline from which to work (Table 11). Ratings of 2, 1 and 0 are used to rank parameters as to their importance for site preservation and location. Two is considered the highest value. Prehistoric sites were rates as yes (2), and no (0), or unknown (1), depending on whether field data recorded the presence or absence of present coastal sites in the area. Unknown (1) rates are given to those areas where field observations are lacking. Bottom sediment type was divided into mud (2), sand (1), or gravel (0). A higher probability was assigned to fine-grained silt and mud sediment localities as they tend to provide better stability and likelihood of artifact preservation. Inundation rate was denoted as fast (2), intermediate (1), or slow (0), depending on bathymetery characteristics and their relationship to rate of inundation of shorelines by rising sea level. Exposure was listed as protected (2), seasonally variable (1), or open (0), to describe the physical relationship between site location and exposure to wind and wave action.

TABLE 11

RATING OF PARAMETERS TO DETERMINE PROBABILITY OF SITE LOCATION

PARAMETER	KEY	RATING
PREHISTORIC SITES:	YES	2
	UNKNOWN	1
	NO	0
BOTTOM SEDIMENT TYPE :	MUD	2
	SAND	1
	GRAVEL	0
INUNDATION RATE	FAST	2
	INTERMEDIATE	1
	SLOW	0
EXPOSURE :	PROTECTED	2
	SEASONALLY VARIABLE	1
	OPEN	0

Data on the four parameters described, that is, prehistoric site location, bottom sediment type, inundation rate and exposure, as well as a projected lowered sea level contour of 10 meters from present, were plotted on baseline maps obtained from the University of Washington. Figure 28 is an example of one of these predictive maps for San Juan County. The lower sea level contours were drawn from Navy bathymetery maps and National Oceanic and Atmospheric Administration nautical charts. Bottom sediment data were analyzed from sediment maps from the University of Washington. Available data on prehistoric site distribution were obtained from the Washington State Office of Archaeology and Historic Preservation.

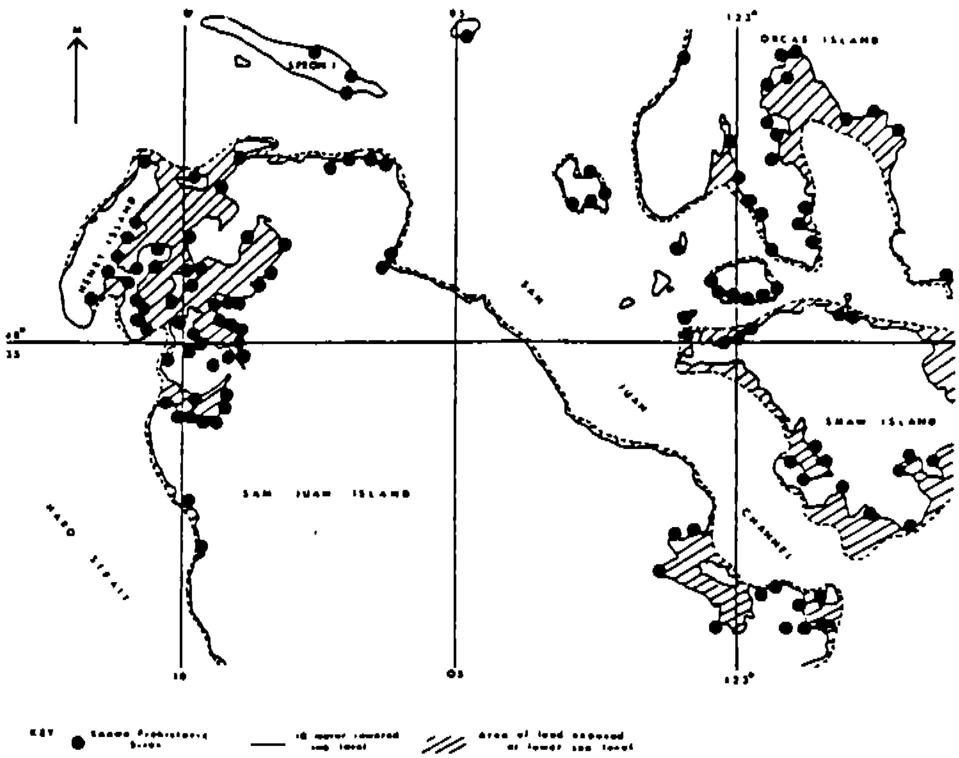


Figure 28. Predictive Map: San Juan Islands

Table 12 summarizes data related to various coastline sections in the Puget Sound Lowland. The four parameters of prehistoric site location, bottom sediment type, inundation rate and exposure were rated according to the data found for each section. Note that average values were given to bottom sediments depending on the variety of sediments found in a study zone.

Rating of probability of preservation was found by adding the values of the three environmental parameters of bottom sediments, inundation rate and exposure. The sum values were then rated as good, fair or poor. Probability of site location incorporates known prehistoric site information and environmental data; it is also rated good, fair or poor depending on the sum values. It should be noted that probability of site location nearly mirrors ratings for probability of preservation thus emphasizing the importance of environmental analysis for predicting site survival.

TABLE 12

PROBABILITY OF SITE LOCATION FOR ISLAND AND JEFFERSON COUNTIES (CHART 807)

( )= RATING

LOCATION	PREHISTORIC[a] SITES	BOTTOM[b] SEDIMENTS	INUNDATION[c] RATE	EXPOSURE[d]	PROBABILITY[b+c+d] OF PRESERVATION	PROBABILITY[a+b+c+d] OF LOCATION
DECEPTION PASS	YES (2)	GR.-SAND (.5)	S (0)	0 (0)	(.5) POOR	(2.5) POOR
PT. PARTR.	NO (0)	GR.-SAND (.5)	F (2)	0 (0)	(2.5) FAIR	(2.5) POOR
PENN COVE	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
SEQUIM BAY	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
PROTECTION IS.	NO (0)	GR.-SAND (.5)	S (0)	0 (0)	(.5) POOR	(.5) POOR
PORT TOWNSEND	YES (2)	GR.-SAND (.5)	S (0)	SV (1)	(1.5) POOR	(3.5) FAIR
INDIAN I.	YES (2)	SAND-MUD (1.5)	F (2)	P (2)	(5.5) GOOD	(7.5) GOOD
MARROW-STONE I.	UN. (1)	SAND-MUD (1.7) GR.	S (0)	SV (1)	(2.7) FAIR	(3.7) FAIR

RATING PROBABILITY OF PRESERVATION: 0-2.0	POOR	RATING PROBABILITY OF LOCATION: 0-2.7	POOR
2.1-4.0	FAIR	2.8-5.4	FAIR
4.1-6.0	GOOD	5.5-8.0	GOOD

It is apparent from reviewing Table 12 that sites which have the characteristics of sand and mud bottom sediment types, in combination with a fast inundation rate and being located in a protected embayment, have a high probability for artifact preservation. One such site is Sequim Bay located along the Strait of Juan de Fuca.

Further research is needed in charting submerged river channels as a possible method for site location. Knowledge of sedimentation rates and geochemistry of sediment types for high site potential areas is required to determine the quality of site preservation and whether excavation would be feasible. Finally specific areas need to be investigated in the field to test the predictive capability of the model and to generate data in order to modify and refine it.

In conclusion the predictive model developed has generated a list of potential archaeological site locations under water in each of the Washington counties located along Puget Sound and the Strait of Juan de Fuca. The use of environmental characteristics of the area, coupled with known prehistoric sites, has enabled us to determine a preliminary evaluation of where potential underwater prehistoric archaeological sites may occur and the probability of site preservation. The next step is to carry out field investigations in specific regions of the Puget Sound Lowland to validate and upgrade the model. Only then can it develop into a viable research, as well as resource management, tool.

REFERENCES CITED

Easterbrook, Donald J., 1969. Pleistocene chronology of the Puget Lowland and San Juan Islands, Washington. Geological Society of America Bulletin 80(11):2273-2286.

Gagliano, Sherwood M. (editor), et al., 1977. Cultural resources evaluation of the northern Gulf of Mexico continental shelf. Vol. I: Prehistoric cultural resource potential. Coastal Environments, Inc., Baton Rouge, Louisiana.

Larsen, Curtis E., 1972. The relationship of relative sea level to the archaeology of the Fraser River Delta, British Columbia. Paper presented at the 1972 Annual Meeting of the Geological Society of America, Minniapolis, Minnesota.

Ruppe, Reynold J., 1980. The archaeology of drowned terrestrial sites: a preliminary report. Bureau of Historic Sites and Properties Bulletin No. 6.

Thorson, Robert M., 1980. Ice sheet glaciation of the Puget Lowland, Washington, during the Vashon Stade (Late Pleistocene). Quaternary Research 13(3):303-321.

THE GEOLOGIC CONTEXT OF THE MCFADDIN BEACH AREA, SOUTHEAST TEXAS

Saul Aronow

Department of Geology, Lamar University

McFaddin Beach on the upper part of the Texas coast lies between Sabine Pass and High Island, a salt dome-elevated Beaumont Formation inlier. The shoreline here is transgressive and the narrow beach deposits in successive hurricanes have moved inland over the Holocene marsh deposits that lie between the beach and the outcrop area of the Beaumont Formation to the northwest. The beach, especially after great storms and hurricanes, is the site of deposition of sparse vertebrate remains and prehistoric artifacts.

This portion of the Texas coast is about the only one in which a considerable width (1.5 to 15 km) of Holocene marsh separates the Beaumont outcrop area from the Gulf. Elsewhere the Gulf is bounded by barrier islands, peninsulas (long spits) or eroding Holocene delta plain deposits (Aronow and Kaczorowski, in press, and Morton 1979).

The Holocene marsh deposits in most places are probably less than 3 m thick and rest directly upon a shelf of Beaumont Formation. The seaward margin of the Beaumont outcrop area to the northwest has a digitate, highly crenulated pattern and represents a sequence of small birdsfoot deltas--the successive mouths of the laterally meandering paleo-Trinity River of Late Pleistocene age (Aronow, 1971, and Univ. Texas Bureau Economic Geology, 1968). The Beaumont Formation between the Holocene Neches River and Cedar Bayou (just east of the San Jacinto River) was laid down by a mainly suspended load (Galloway) paleo-Trinity River whose several deltas are roughly the size and shape of the modern delta of the Trinity.

This uniquely preserved--for the Texas coast--area may be explained by reference to the areal distribution and altitudes of the several portions of the Late Pleistocene Ingleside (Price, 1933, 1947, and Wilkinson, et al., 1975) barrier-strandplain system. South and southwest of West (Galveston) Bay the Ingleside is landward of and marginal to the several bays and lagoons of the Texas coast and is generally less than 3 m above sea level (Univ. Texas Bureau of Economic Geology, 1975). Northeast of Galveston Bay (Univ. Texas Bureau of Economic Geology, 1968) beginning at Smith Point the remnants of the Ingleside rise progressively from 3 m to more than 9 m above sea level and terminate in the vicinity of the Houston River in southwestern Louisiana (Price, 1947). With this increase in altitude the Ingleside is located increasingly inland from the Gulf and is enclosed by the Beaumont outcrop area. On the assumption that the fragments of the Ingleside were defined by the same water plane we may conjecture that either the local area has been uplifted or the rest of the Texas coast has subsided. In either case it led to the preserving of the McFaddin Beach area at the edge of the marsh. The beach and adjacent marsh area are underlain by a portion of the Beaumont that was offshore when the several Beaumont-age deltas to the northwest were deposited.

The vertebrate remains and prehistoric artifacts found along McFaddin Beach have been described (Long, 1977, and Russell, 1975). The vertebrate material, characterized as Rancholabrean, that is, post-Illinoian or Late Pleistocene, includes bones and teeth of large extinct mammals as well as smaller still extant forms from a variety of environments: South American tropical forest (e.g., capybara, jaguar, giant armadillo), grassland (e.g., bison, horse, mammoth), forest (e.g., mastadon), and arid to semi-arid (e.g., black-tailed prairie dog). These are believed to represent a temporal succession of environments rather than contemporaneously existing ones. The fossils and artifacts are transported to the beach as detritus by waves and currents and have not been found in place in any geologic unit.

Several scenarios for the source(s) of the fossils and artifacts can be suggested--bearing in mind that the offshore area was exposed from a sea-level "low" about 18,000 years B.P. to about 2500 to 3000 years B.P. when sea level was stabilized: (a) both artifacts and fossils derived from the Beaumont, (b) some of each derived from the Beaumont, and some of each from scattered surface sources when the continental shelf was exposed, (c) both fossils and artifacts from surface sources only, (d) some fossils from the Beaumont, and some fossils and all artifacts from surface sources, or (e) all fossils from the Beaumont and all artifacts from the surface sources. Scenarios (b), (c), and (d) are among the more plausible ones in light of a single radiocarbon date 11,100 + 750 years B.P. on an elephant tusk recovered from the beach (Long, 1977). The evaluation of the artifacts relative to these scenarios will not be attempted.

Because of the multiplicity of possible scenarios, the ages of the several geologic units in the region relative to a generalized Wisconsinan stratigraphic sequence (Beard et al., 1982) may be of interest.

The Beaumont Formation has yielded two sets of radiocarbon dates: (a) ~25,00 years B.P. to ~30,000 years B.P. and (b) greater than ~40,000 years B.P. and "dead." The younger dates might fall into the Farmdalian high-sea level stage; the older, the Mid-Altonian, or even the Sangamon high-sea level stages. The Ingleside depositional features could be placed in either of these older high-sea level stands. The radiocarbon dates for the Deweyville terrace complex (straths and large-radii meander scars, alluvial terraces containing relict channels with large-radii meanders) span ~13,000 years B.P. to ~25,000 years B.P., thus placing the unit partly in the Farmdalian high sea-level stage and partly in the Woodfordian low sea-level stage. These dates are all older than the Two Creekan (~11,500 years B.P.) and overlap the younger Beaumont dates. The Deweyville complex along the coast--at the mouths, for example, of the San Jacinto and Trinity Rivers--descends below sea level and was inundated by the post-18,000-year B.P. sea-level rise. Possibly some artifacts might be contemporaneous with part of the Deweyville complex. Should we choose to define the Gulf Coast Holocene as post-Deweyville, some fossils and artifacts might be considered as Early Holocene.

REFERENCES AND NOTES

Aronow, S., 1971, Quaternary geology of Chambers and Jefferson Counties, in Wesselman, J. B., Ground-water resources of Chambers and Jefferson Counties, Texas: Texas Water Devel. Bd. Rept. 133, p. 34-53. See figs. 20 and 22.

Aronow, S., and Kaczorowski, R. T., in press, The coastline of Texas, in Bird, E. C. F., and Schwartz, M. L., editors, The world's coastlines: Stroudsberg, Penn., Hutchinson Ross Publ. Co.

Beard, J. H., Sangree, J. B., and Smith, L. A., 1982, Quaternary chronology, paleoclimate, depositional sequences, and eustatic cycles: Am. Assoc. Petroleum Geologists Bull., vol. 66, p. 158-169. See figs. 1 and 4.

Galloway, W. E., Catahoula Formation of the Texas Coastal Plain: Univ. Texas Bur. Econ. Geology Rept. Invest. 87. See table 1.

Long, R. J., 1977, McFaddin Beach: Patillo Higgins Ser. Nat. Hist. and Anthro. no. 1, Spindletop Museum, Lamar University, Beaumont, Texas. See p. 7 for radiocarbon date.

Morton, R. A., 1979, Temporal and spatial variations in shoreline changes and their implications, examples from the Texas Gulf Coast: Jour. Sed. Petrology, vol. 49, p. 1101-1112. See p. 1103-1104.

Price, W. A., 1933, Role of diastrophism in topography of Corpus Christi area, South Texas: Am. Assoc. Petroleum Geologists Bull., vol. 907-962. See figs. 2 and 6.

Price, W. A., 1947, Equilibrium of form and forces in tidal basins of coast of Texas and Louisiana: Am. Assoc. Petroleum Geologists Bull., vol. 31, p. 1619-1663. See fig. 1.

Russell, J. D., 1975, Identification of Pleistocene fossils from McFaddin Beach, Texas: unpublished master's thesis, Dept. of Biology, Lamar Univ., Beaumont, Texas.

Univ. Texas Bureau Economic Geology, 1968, Geologic Atlas of Texas, Beaumont and Houston Sheets, scale 1:250,000.

Univ. Texas Bureau Economic Geology, 1975, Geologic Atlas of Texas, Beeville-Bay City and Corpus Christi Sheets, scale 1:250,000.

Wilkinson, B. H., McGowen, J. H., and Lewis, C. R., 1975, Ingleside strandplain sand of central Texas coast: Am. Assoc. Petroleum Geologists Bull., vol. 59, p. 347-352.

ARCHAEOLOGY AND PALEOGEOGRAPHY OF THE MCFADDIN BEACH SITE, JEFFERSON COUNTY, TEXAS

Charles E. Pearson
Coastal Environments, Inc.

Archaeological and geological data from the McFaddin Beach site in eastern coastal Texas were examined in the context of the past 15,000 years of environmental history of the area. The site consists of wave-washed cultural deposits of Paleo-Indian age and later as well as large quantities of fossilized late Pleistocene faunal remains. The relationship of these materials to onshore and offshore late Pleistocene and early Holocene landform sequences were reviewed. The evidence suggests that cultural and faunal materials are being eroded from a number of locales on the surface of late Pleistocene, Trinity River deltaic formations and overlying Holocene deposits immediately offshore of the present beach. It is proposed that the Paleo-Indian cultural materials were associated with features such as the levees along channel courses, oxbow lakes, and marsh and swamp margins which remained as relict, though preferred, settlement habitats long after the Trinity River abandoned this area about 25,000 years B.P. It is highly likely that early man material will be found in association with similar relict deltaic features which are now exposed as the land surface just inland from the coast. It is anticipated, however, that these sites will be difficult to locate since they probably existed as brief, scattered occupations which have been obscured by processes of erosion and sedimentation.

THE EFFECTS OF SEA LEVEL RISE AND SUBSIDENCE ON PREHISTORIC SITES IN COASTAL LOUISIANA

Thomas M. Ryan
Corps of Engineers

The Mississippi Deltaic Plain hydrologic regime integreates a set of complex ecological processes which control biological productivity as well as community composition and extent. Since most of the deltaic plain lies at or near sea level, any changes in the position of the land and sea would alter community composition over hundreds of square miles of the deltaic plain.

Recent work by Colquhoun and Brooks combining both geological and archaeological data supports the occurrence of late Holocene sea level fluctuations along the South Carolina coast. The available archaeological data suggests relatively high sea level stands during the temporal intervals from 4,200-3,700 years B.P., 3,100-2,850 years B.P., 2,250-1,750 years B.P., and 1,600-1,000 years B.P. The geological data indicates lower sea level stands at 3,100 years B.P. and between 2,695 and 2,330 years B.P., with higher stands before and after these dates. The observed fluctuations are between 1 and 2 meters and occur with a frequency of approximately 400-500 years. The South Carolina data correlate with the transgressive and regressive phases reported from Northwest Europe and the authors propose glacio-eustatic mechanisms to explain the fluctuations recorded from both coasts.

Excavation of Big Oak Island, a Tchefuncte Period shell midden located in the deltaic plain east of New Orleans, revealed a stratigraphic sequence of natural and cultural deposits. The basal component consists of a peaty muck rich in cultural remains. The basal component is sealed by a massive sterile shell beach which is in turn covered by a Rangia Shell Midden. The basal component holds a radiocarbon date of 2,470 + 65 years

B.P. while the Shell Midden which overlies the beach has dates of 2,325 + 60 years B.P., 2,220 + 200 years B.P., and 2,185 + 70 years B.P. The beach is a transgressive feature and dates between approximately 2,470 and 2,325 years B.P.

According to the Colquhoun-Brooks oscillation curve, the interval between 2,695 and 2,330 years B.P. was characterized by a low sea level stand on the South Carolina coast. The Louisiana data support a transgression during this interval rather than a regression suggestive of the South Carolina curve. This discrepancy may be the result of high regional subsidence rates which characterize the Mississippi Plain.

POTENTIALS OF DISCOVERY OF HUMAN OCCUPATION SITES ON THE CONTINENTAL SHELF AND NEARSHORE COASTAL ZONE

Daniel F. Belknap

Department of Geological Sciences, University of Maine-Orono

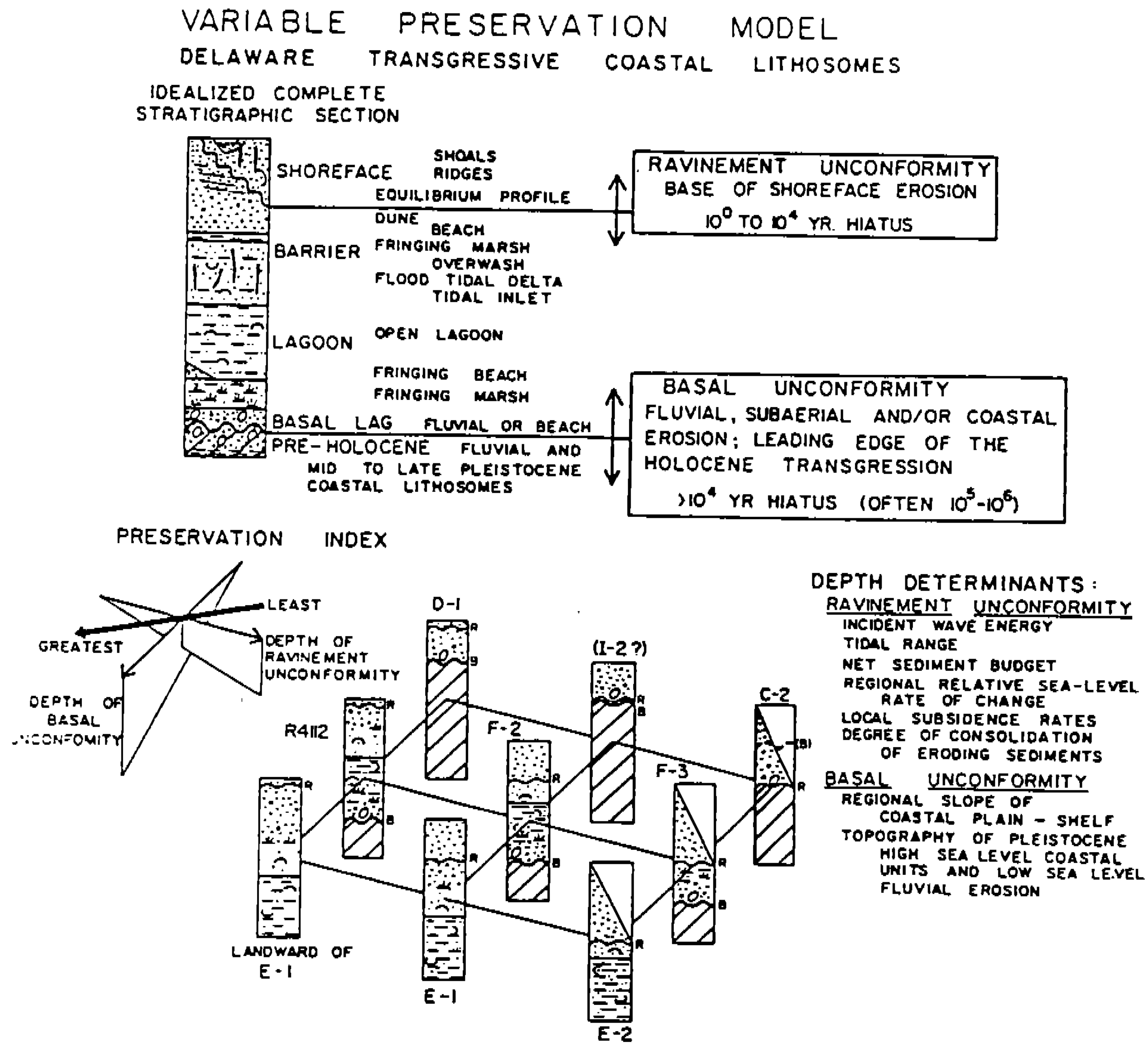
Archaeological sites on the continental shelf have been exposed to the Holocene transgression, as post-glacial sea level rose and drowned previously exposed sites. For these sites to be preserved the migrating zone of shoreface erosion must pass them by or they must be extremely resistant. Caves or quarried stone sites might be preserved in the eastern Mediterranean and elsewhere, but in the U.S. Gulf and Atlantic coastal plain it is extremely unlikely that middens and occupation sites on unconsolidated sediments would survive shoreface erosion.

To understand archaeological preservation potential general coastal lithosome preservation potential must be understood. Belknap and Kraft

(1981, 1984 in press) have modeled preservation potential of Delaware's transgressive barrier-lagoon and headland beach shoreline. Important factors in the model include rate of local relative sea-level rise, depth of shoreface erosion, which is in turn related to incident wave energy, tidal range, and sediment budget, and the factor of antecedent geology. The latter is a critical control. Deep pre-Holocene valleys contain more complete stratigraphic sections while there is no preservation of Holocene sediments over ancient interfluves now in the shoreface. Figure 29 is an idealized Holocene stratigraphic column for coastal Delaware which contains two unconformities: the ravinement surface (R) and the basal unconformity (B). The relative preservation potential (or, conversely, the length of hiatus in sedimentation) depends on position of these two unconformities. Below the idealized stratigraphic column are shown nine cores from the Delaware Atlantic shoreface which apply to this model, in a hierarchy of relative preservation. Maximum preservation occurs (Core E-1) where basal unconformity is deep, in pre-Holocene valleys, and where ravinement unconformity is shallow (shorthand notation B_dR_s). Conversely, minimum preservation occurs where basal unconformity is shallow and ravinement unconformity is deep (notation B_sR_d, Core C-2).

Seismic profiling and vibracoring on the shoreface and inner shelf off Delaware have allowed identification of the extensive paleofluvial Delaware River and its tributaries. The flanks of these valleys, filled with thick Holocene sediments, are the only likely locations for preserved archaeological sites offshore.

Figure 30 is a conceptual model of geologic evolution of coastal archaeological sites in the U.S. mid-Atlantic coast (from Kraft et al., 1983). The vertical axis represents the preservation potential of an archaeological site. The horizontal axis is a measure of the relative age of a site. For actual examples, this axis will stretch or shrink depending on rate of shoreline movement and original distance of the site from the shoreline. The relative shoreline position at present is shown below. The horizontal axis should not be misinterpreted as a strictly linear, quantitative measure of time. Similarly, the vertical axis is also relative: architectural ruins of



Depth of unconformities:

BASAL \ RAVINEMENT	Shallow	Moderate	Deep
Shallow	B_sR_s	B_sR_m	B_sR_d
Moderate	B_mR_s	B_mR_m	B_mR_d
Deep	B_dR_s	B_dR_m	B_dR_d

Figure 29. Variable Preservation Model for CoastalLithosomes From Belknap and Draft, 1984 (in press).

quarried stone would be far more resistant to shoreline processes than Amerindian middens, but a midden or mound is more resistant to earthquakes. Thus, the relative preservation potentials are qualitative. Figure 31 shows 5 examples of archaeological sites in typical mid-Atlantic geographic settings. In addition, the positions of similar sites after sea-level rise and coastal erosion continue are shown within the faces of the block diagram.

On the mid-Atlantic coast, sites initially pass through a subaerial degredation phase (I, Figure 30; 1-5, Figure 31) in which running water, frost, and biological activity alter the site. Phase II is common for sites on the landward side of marshes and lagoons, such as Island Field, which are buried by tidal marsh or lagoon sediments with continuing sea-level rise (2',3',5', Figure 31). In these quiet environments preservation is enhanced (dashed line, Figure 30). Probability of discovery, however, falls with burial (dotted line). Phase III is as the erosive shoreface passes the site. Degree of preservation is dependent on the depth of scour, which reaches 10 meters on the Atlantic coast and 3 to 4 meters on the Delaware Bay coast. Thus, probability of destruction is dependent in part on whether a site is intersected by a deeply eroding oceanic shoreface (line a, Figure 30; e.g. Cape Henlopen lighthouse, 1926 or site 1', Figure 31) or a shallowly eroding estuarine shoreface (line b, Figure 30). Five to ten meters depth of scour is certainly sufficient to remove most Amerindian archaeological sites on a gently sloping coastal plain. Delayed arrival of the shoreface, however, such as in a valley floor on its flanks where it has been subsequently inundated by marsh or lagoonal mud (2', 3', 5', Figure 31) may allow preservation as the shoreface passes above the site. The zone of erosion passes above the site because sea level has risen in the interim. Discovery potential (dotted line, Figure 30) jumps briefly for buried sites if they are re-exposed at the shoreface, but declines as rapidly as a non-buried site thereafter.

These models have been used to predict locations of submerged archaeological sites on the U.S. mid-Atlantic coast and in the eastern Mediterranean (Kraft et al., 1983). To be useful, a detailed seismic profiling grid and long vibracores would be necessary to locate preserved sites. As

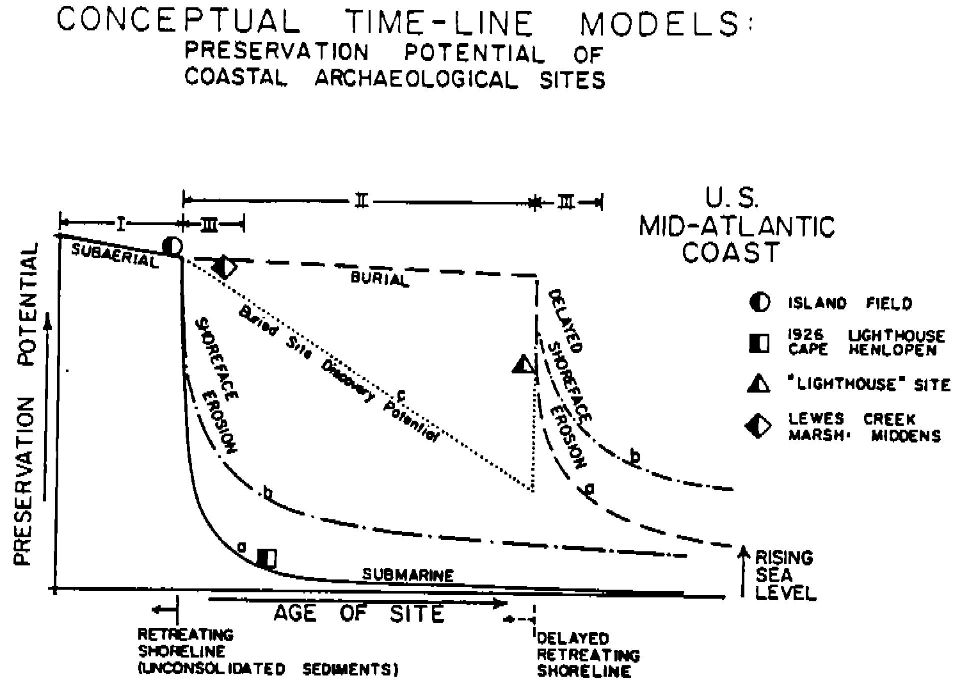


Figure 30. Archaelogical Site Preservation Model From Kraft et al., 1983.

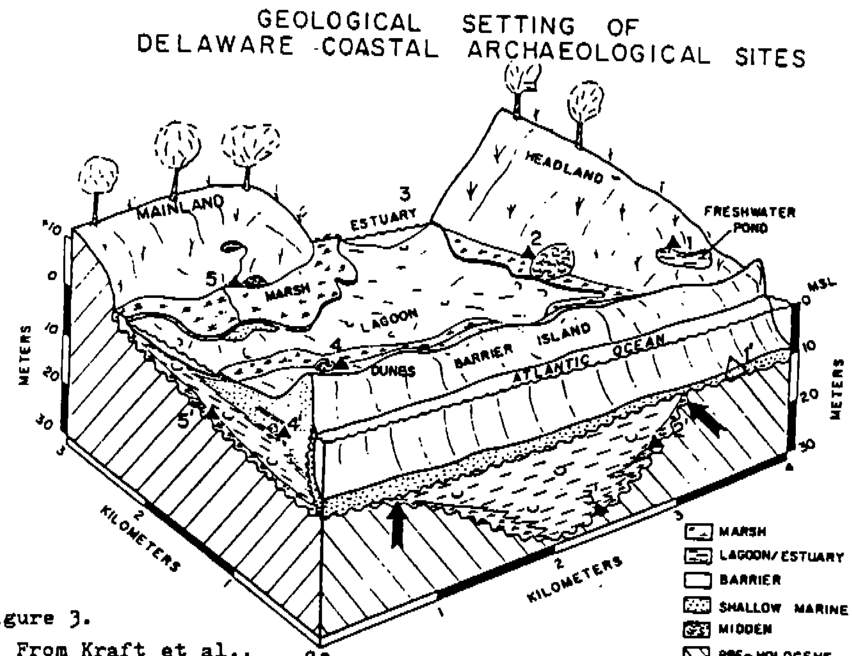


Figure 3.
From Kraft et al., (1983)

Figure 31. Archaelogical Site Geological Model From Kraft et al., 1983.

yet this has not been attempted in the mid-Atlantic region. The model is clearly applicable to other areas, however, such as the Gulf coast. It is still unlikely that sites will be found, unless they are extremely densely distributed. Only likely potential sites for occupation or middens can be identified. It is extremely unlikely that a site exposed to shoreface erosion would survive. Only sites buried deep in valleys, bypassed by the shoreface erosion zone because of relative sea-level rise, will remain. Also, for these reasons older sites have a higher potential for preservation than younger sites.

This discussion has been based on several years of research at the Department of Geology, University of Delaware, and incorporates the ideas of co-authors John C. Kraft and Ilhan Kayan. The data was collected using Delaware Sea Grant, Office of Naval Research, and Delaware Department of Natural Resources and Environmental Control grants.

REFERENCES

Belknap, D. F. and Kraft, J. C., 1981. Preservation potential of transgressive coastal lithosomes on the U.S. Atlantic shelf: Marine Geology, v. 42, p. 429-442.

Belknap, D. F. and Kraft, J. C., 1984 (in press). Influence of antecedent geology on stratigraphic preservation potential and evolution of Delaware's barrier systems: in G. Oertel, P. Rosen, eds., Marine Geology Special Issue, Barrier Island Evolution.

Kraft, J. C., Belknap, D. F. and Kayan, I., 1983. Potentials of discovery of human occupation sites on the continental shelves and nearshore coastal zone: in P. M. Masters and N. C. Flemming, eds., Quaternary Coastlines and Marine Archaeology, Academic Press, p. 87-120.

SUBMARINE STONE AGE SETTLEMENTS IN DENMARK

Per Smed Philipsen
Danish Ministry of the Environment

INTRODUCTION

During the last decades, several submerged Stone Age settlements have been detected in the vast areas of shallow water surrounding Denmark. Unlike most land sites, the submarine sites are very rich in artifacts of organic material, manily because the artifacts are embedded in gyttja-layers (mud and turf) extremely deficient in oxygen, resulting in the preservation of the artifacts until the present day.

PROJECT HISTORY

Although Denmark is a very small country (approximately 26,000 square miles), because of the many inlets, creeks, coves, and islands, the total length of today's coastline is more than 4,500 miles. The many sheltered parts of the coast protect most of the inundated sites from washing out (erosion).

From well-preserved artifacts washed ashore along the coasts we have obtained a rough knowledge of the location of the sites, but not why the location was chosen. The latter problem required actual excavations.

POTENTIAL

So far only a few sites have been excavated. Methods of excavation are identical to those used on dry land: fixpoints and systems of coordinates are laid out and attached to the seabed. Every square meter is systematically excavated, plans and sections are drawn upon the seabed, and the location of each find is measured vertically and horizontally. The excvavation techniques differ considerably from land excavations: above the site a ship or a raft with pump gear is anchored. The pumps supply the airlifts and the injectors with air and water. Every square meter is excavated with a traditional trowel or by hand. The two types of pumps are solely used for transporting excavated material away and maintaining good visibility.

The stratigraphy of these sites is extremely good. The deposits alternate between thin layers of coarse sand and thick layers of organic mud, peat, and turf (gyttja) with varying consistency and compositon. In the gyttja-layers Stone Age artifacts of all kinds of material are embedded. Especially organic material is well preserved. That is material such as wood and bark, bone and antler, bast and senew plus nuts, acorns, roots, leaves, insects, etc.

The wooden objects dominate the finds: paddles (among them one completely ornamented), dug-out canoes, bows and arrows, leister prongs for fishing spears, handles, etc. Tools of bone and antler are very common as well: axes, knives, needles and points, fishing hooks (one with the line preserved). Bones are found in large quantities. From these sites the bones are mainly from red deer, wild boar, and roe deer, as well as furred animals such as pine marten, wild cat, otter, and pole cat. Many of them bear distinct marks of butchering or fur skinning. In addition to several isolated finds of human bones embedded in the gyttja layers, a few human graves have been revealed.

PROBLEMS AND PROSPECTS

Most of the settlements detected until the present day date back to late mesolithic in Denmark, which in terms of years is approximately 5,800 - 5,100 B.P. The sites are all located close to the coastline of today (50 - 1,200 feet) and are situated in shallow water (5-18 feet). Until now no early

Mesolithic coastal settlements have been found under water, but several isolated finds of antler, bone, and flint embedded in submarine bogs have been brought to the surface from somewhat greater depth in the course of fishing or extraction of raw materials from the seabed. These older sites still need to be located.

Unfortunately, the older bogs (and thereby the settlements) are most often covered by sand--and today the seabed is completely flat. Thus it is impossible for divers to detect them. This job requires other methods.

One of these methods is seismic registration, mapping a given area with a low frequency echo sounder. The Danish Ministry of Environment is currently running a project designed to detect submarine sites and wrecks by means of a sub-bottom profiler and a side-scan sonar. This part of the project is still quite new and as yet only at an experimental stage.

The electronic registration forms part of a nationwide registration. All archaeological information is being computerized, and in a very short time it will be possible for industry and others to order a computerplotted sea chart with the archaeologically important areas plotted out. The only information needed to order charts like this will be dimensions and co-ordinates of the map corners. Besides continued registration, future research will be concentrated on attempting to develop new models for the detection of depth and possible location of the prehistoric settlements. This work requires close cooperation between marine archaeologists and quarternary geologists as well as industries involved in exploiting the resources of the sea. This cooperation seems to ensure that the main parties concerned--archaeology and industry--are aware of the interests of one another and accept these.

REFERENCES

Andersen, S. H., 1980: Tybrind Vig - a preliminary report on a Submerged Ertebolle Settlement on Little Belt. In: Antikvariske Studier, vol. 4, pp. 7-22. ISBN 87-503-3356-9 ISSN 0106-1860. Copenhagen 1980.

Andersen, S. H., 1983: A Stone Age Boat from Tybrind Vig. In: Antikvariske Studier, vol. 6, pp. 162-172. ISBN 87-503-4768-3 ISSN 0106-180. Copenhagen 1983.

Davidsen, K., 1983: Neolithic Underwater Votive Offerings. In: Antikvariske Studier, vol. 6, pp. 127-136. ISBN 87-503-4768-3 ISSN 0106-1860. Cph. 1983.

Fisher, A. & Sorensen, S. 1983: Stone Age on the Danish Sea Floor. In: Antikvariske Studier, vol. 6, pp. 104-126. ISBN as above.

Skaarup, J. 1983: Stone Age Settlement Sites in the South Funen Archipelago. In: Antikvariske Studier, vol. 6, pp. 137-161. ISBN as above.

"Antikvariske Studier" is an annual paper from the National Agency for the Protection of Nature, Monuments and Sites (named Fredningsstyrelsen). The book can be ordered from: Statens Indkob, Bredgade 20, 1260 Copenhagen K. Denmark.